

Supplementary Information (SI) for RSC Applied Polymers.

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Supplementary Information

Engineering protein-based fiber-reinforced pneumatic actuators

Sandra Edward^{a,b}, David Wilcoski^b, Natalie Taylor^b, Jason Robinson^b, Bryan Kaehr^c, Girish Krishnan^d, and Holly Golecki^{b*}

^aMechanical Sciences and Engineering Department
Grainger College of Engineering, University of Illinois Urbana-Champaign
Urbana, IL 61801

^bBioengineering Department
Grainger College of Engineering, University of Illinois Urbana-Champaign
Urbana, IL 61801

^cAdvanced Materials Laboratory
Sandia National Laboratory
Albuquerque, NM 87106

^dIndustrial Systems and Engineering Department
Grainger College of Engineering, University of Illinois Urbana-Champaign
Urbana, IL 61801

*Corresponding author: Holly Golecki (golecki@illinois.edu)

Raman Spectroscopy Method

To understand the material composition of the gelatin material utilized to make the FREEs, Raman spectroscopy was conducted on cross-section of the demolded and dehydrated gelatin mixture that was not yet wound with the silk fibers. With the Horiba Scientific, LabRAM HR spectrometer, we used a laser of 532 nm, no density filter, a diffraction grating of 300 g/mm, a hole of 100 μm , and a slit of 100 μm , spectra for the different gelatin material was collected at 10 seconds each for 5 acquisitions. Spectra were collected at five spots along the bioFREE matrial cross-section.

Raman spectroscopy to check material composition and homogeneity

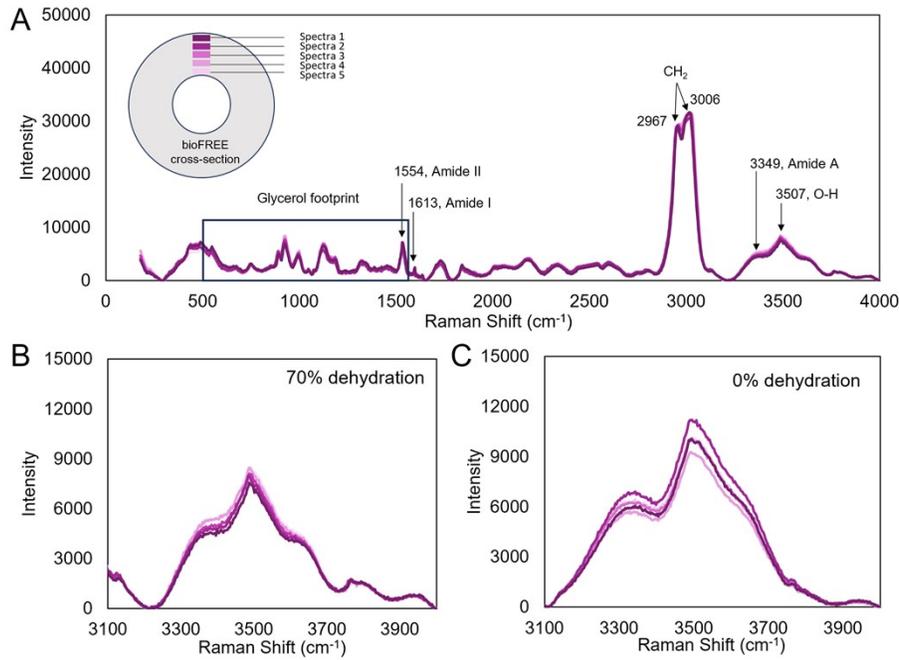


Fig. S1. Raman spectroscopy material analysis. (A). Spectra collected along the cross-section of the 70% dehydrated bioFREE from the outermost edge (Spectra 1) to the innermost edge (Spectra 5) of the bioFREE. The peaks aligned with the peaks of the constituent materials of gelatin, glycerol and water.¹⁻⁴ (B) Spectra focusing on the gelatin and water peaks at 3349 cm^{-1} and 3507 cm^{-1} respectively for the 70% dehydrated bioFREE sample, and (C) the 0% dehydrated bioFREE sample.

Raman Spectroscopy to assess gelatin-silk interface

To understand the nature of the interface between the silk fiber and the gelatin matrix, we analyzed the Raman spectra of the gelatin matrix, the silk, and the boundary of a cross-section of a bioFREE (Fig. S2).

We find no evidence of chemical interactions at the interface because spectra taken at the boundary corresponds to either the gelatin matrix or the silk fiber material⁵ spectra (Fig. S2. B, C, D). This could be because the spectra identifies the material closest to it, and no other spectra of new materials were identified.⁶ Additionally, tensile tests were conducted on a microtensile stage, and the results identified a similar lack of chemical bonds.⁷ These two tests indicate that the interface between the gelatin matrix and the silk fiber are primarily due to the saturation of the gelatin matrix between the silk fibers.

To collect the Raman spectra for this experiment, the hole size was adjusted to 20 μm . The other parameters remain the same as in the previous section.

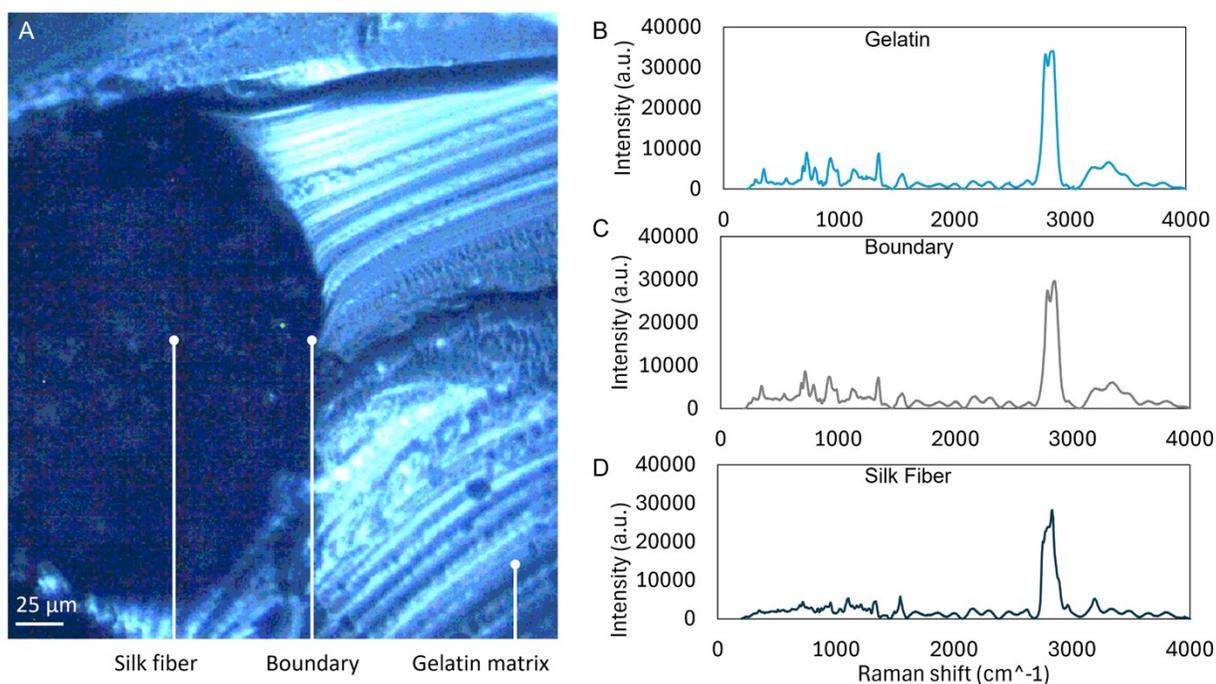


Fig. S2. (A) Raman spectroscopy image of the interface between the gelatin matrix and the silk thread. Raman spectroscopy of (B) the gelatin matrix, (C) the boundary, and (D) the silk fiber.

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